BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

As rescanning documents *will not* correct images, please do not report the images to the Image Problem Mailbox.

What is claimed is:

1. A system for winding fibers onto an article, comprising:

a winding station having a controllable speed of rotation, said winding station having mounted thereon at least one bobbin having said fibers thereon;

a conveyor adapted to move said article axially through said winding station;

a sensor adapted to measure axial motion of said article proximate to said winding station; and

a controller adapted to adjust said speed of rotation of said winding station to correspond to said axial motion thereby to wind said fibers onto said article in a predetermined pattern, the controlled operatively coupled to said axial motion sensor.

2. The system as defined in claim 1 further comprising a rotation sensor rotationally coupled to said winding station to measure said speed of said rotation and operatively coupled to said controlled, said controller adapted to adjust a rate of said axial motion to correspond to said speed of rotation as measured by said rotation sensor.

3. The system as defined in claim 1 further comprising a rotation sensor adapted to generate a signal corresponding to said speed of rotation coupled to said controller, said axial motion sensor adapted to generate a signal corresponding to a speed of said axial motion of said article, said controller adapted to adjust said speed of rotation of said winding station in response to output of said rotation sensor to correspond to said measured axial speed of said article.

4. The system as defined in claim 3 wherein said rotational speed of said winding station is controlled so as to maintain a lay angle of said fibers constant to within a tolerance of about one-half degree.

5. The system as defined in claim 2 wherein said rotation sensor is adapted to generate a signal corresponding to a rotational position of said winding station, said axial motion sensor is adapted to generate a signal corresponding to an axial position of said article along said system, and said controller is adapted to adjust said rotational position of said winding station to correspond to said axial position.

6. The system as defined in claim 1 wherein said controller is adapted to adjust said speed of rotation to provide a lay angle of said fibers corresponding to an axial position of said article within said winding station.

7. The system as defined in claim 6 further comprising an integrator coupled to said axial motion sensor, said integrator adapted to generate a signal corresponding to said axial position.

8. The system as defined in claim 6 further comprising a proximity sensor for generating a signal corresponding to said axial position of said article.

9. The system as defined in claim 8 wherein said proximity sensor comprises a magnetic sensor.

10. The system as defined in claim 8 wherein said proximity sensor comprises a capacitive sensor.

11. The system as defined in claim 8 wherein said proximity sensor comprises a gamma ray transmission sensor.

12. The system as defined in claim 1 further comprising a brake rotationally coupled to said bobbin, said brake selectively operable to maintain a selected tension on said fibers as said fibers are wound onto said article.

13. The system as defined in claim 12 further comprising a torque sensor operatively coupled to a motor adapted to rotate said winding station and connected to said controller, wherein said selected tension is determined by measuring a torque exerted by said motor.

14. The system as defined in claim 13 wherein said torque sensor comprises a torque sensing element rotationally coupled to said motor.

15. The system as defined in claim 13 wherein said torque sensor comprises a current sensor connected to an electrical power input of said motor.

16. The system as defined in claim 12 wherein said brake comprises an air brake pressurized by an air supply coupled thereto through a controllable regulator, said regulator receiving a control signal from said controller.

17. The system as defined in claim 12 wherein said brake comprises a magnetic brake.

18. The system as defined in claim 1 further comprising a resin ring coupled to said winding station, said resin ring adapted to apply resin to said fibers prior to winding thereof on said article.

19. The system as defined in claim 18 wherein said resin ring comprises a rotationally fixed inlet for said resin, and a dynamic seal adapted to seal a fiber inlet and a fiber outlet of a chamber wherein said resin is applied to said fibers, said chamber having formed surfaces therein so that said fibers change directed as they pass through said chamber.

20. The system as defined in claim 19 wherein said dynamic seal comprises an inflatable seal.

21. The system as defined in claim 19 wherein said resin is pumped into said chamber under pressure through said rotationally fixed inlet.

22. The system as defined in claim 1 further comprising a pressure source arranged to charge the interior of said article, so that a cross-sectional shape of said article is substantially maintained during winding said fibers on said article.

23. The system as defined in claim 1 further comprising a torsional resonance detector adapted to detect torsional resonance in said winding station coupled to said controller, said controller adapted to adjust at least one of said speed of rotation and a speed of axial motion when torsional resonance is detected by said torsional resonance detector.

24. The system as defined in claim 23 wherein said torsional resonance detector comprises a current measuring circuit coupled to a motor adapted to rotate said winding station.

25. The system as defined in claim 23 wherein said torsional resonance detector comprises a torque sensor coupled to a motor adapted to rotate said winding station.

26. The system as defined in claim 23 wherein said torsional resonance detector comprises a rotation sensor rotationally coupled to said winding station.

27. The system as defined in claim 1 further comprising an axial resonance detector adapted to detect resonance in axial motion of said article, said axial resonance detector coupled to said controller, said controller adapted to adjust at least one of said speed of rotation and a speed of axial motion when axial resonance is detected by said axial resonance detector.

28. The system as defined in claim 27 wherein said axial resonance detector comprises a current measuring circuit coupled to a motor adapted to move said article axially through said system.

29. The system as defined in claim 27 wherein said axial resonance detector comprises a torque sensor coupled to a motor adapted to move said article axially through said system.

30. The system as defined in claim 27 wherein said axial resonance detector comprises said axial motion sensor.

31. A system for winding fibers onto an article, comprising:

a winding station having at least one fiber bobbin thereon;

a conveyor adapted to move said article axially through said winding station; and

a brake rotationally coupled to said at least one fiber bobbin, said brake selectively operable to maintain a selected tension on said fibers as said fibers are wound onto said article.

32. The system as defined in claim 31 further comprising a torque sensor operatively coupled to a motor adapted to rotate said winding station and connected to a controller adapted to control a force exerted by said brake, said tension determined by measuring a torque exerted by said motor.

33. The system as defined in claim 32 wherein said torque sensor comprises a torque sensing element rotationally coupled to said motor.

34. The system as defined in claim 32 wherein said torque sensor comprises a current measuring sensor adapted to measure current drawn by said motor.

35. A system for winding fibers onto an article, comprising:

a winding station having at least one fiber bobbin thereon;

a conveyor adapted to move said article axially through said winding station; and

a resin ring coupled to said winding station wherein said fibers are impregnated with resin prior to winding onto said article, said resin ring comprising a chamber sealed by an inflatable seal disposed where said fibers enter and leave said chamber, a rotationally fixed inlet for said resin, and formed surfaces disposed inside said chamber to change a direction of travel of said fiber therethrough.

36. The system as defined in claim 35 wherein said resin is pumped into said chamber under pressure through said rotationally fixed inlet.

37. A system for winding fibers onto an article, comprising:

a winding station having a controllable speed of rotation, said winding station having at least one fiber bobbin thereon;

a conveyor adapted to move said article axially through said winding station; and

a detector adapted to detect torsional resonance in said winding station coupled to a controller, said controller adapted to adjust a rotational speed of said winding station when torsional resonance is detected.

38. The system as defined in claim 37 wherein said torsional resonance detector comprises a current measuring circuit coupled to a motor adapted to rotate said winding station.

39. The system as defined in claim 37 wherein said torsional resonance detector comprises a torque sensor coupled to a motor adapted to rotate said winding station.

40. The system as defined in claim 37 wherein said torsional resonance detector comprises a rotation sensor coupled to said winding station.

41. A method for making a wound-fiber reinforced article, comprising:

moving said article through a winding station at a measured rate of speed;

rotating fibers around said article at a selected rotational speed to wind said fibers around said article; and

controlling said measured rotational speed to match said measured rate of speed at which said article moves through said winding station so that said fibers are wound in a predetermined pattern.

42. The method as defined in claim 41 wherein said controlled rotational speed is selected to provide a helical wind pattern to said fibers having a lay angle within a tolerance of about one half degree.

43. The method as defined in claim 41 wherein said controlled rotational speed is selected to provide a helical wind pattern to said fibers having a lay angle corresponding to an axial position of said article in said winding station.

44. The method as defined in claim 43 further comprising controlling a tension on said fibers during winding thereof about said article.

45. The method as defined in claim 43 wherein said article comprises a liner having an end connector inserted therein, said end connector having traps thereon, said tension increased during winding of said fibers across said traps, said lay angle increased during winding of said fibers across a tapered section of said connector, said lay angle decreased during winding said fibers across a junction of said liner to said connector.

46. The method as defined in claim 44 wherein said controlling said tension comprises measuring a torque exerted by a motor used to rotate said winding station and adjusting a force exerted by a brake retarding movement of said fibers in response to said measuring of said torque.

47. The method as defined in claim 41 further comprising applying resin to said fibers prior to winding on said article.

48. The method as defined in claim 41 further comprising detecting torsional oscillations in said measured rotational speed and adjusting said rotational speed to minimize said torsional oscillations.

49. The method as defined in claim 48 wherein said detecting torsional oscillations in said measured rotational speed comprises detecting torsional oscillation components in a current draw of a motor used to rotate said winding station.

50. The method as defined in claim 48 wherein said detecting torsional oscillations in said measured rotational speed comprises detecting torsional oscillation components in a spectral analysis of rotational speed of said winding station.

Sub A1

51. A system for winding fibers onto an article, comprising:

a winding station having a controllable speed of rotation, said winding station having at least one fiber bobbin thereon;

a conveyor adapted to move said article axially through said winding station;

a sensor adapted to measure axial speed of said article proximate to said winding station, said axial speed sensor comprising a wheel in frictional contact with said article coupled to a rotary encoder;

a sensor adapted to measure said speed of rotation of said winding station, said rotational speed sensor comprising a rotary encoder rotationally coupled to a motor adapted to rotate said winding station;

a controller adapted to adjust said speed of rotation of said winding station in response to output of said sensor adapted to measure said speed of rotation, said rotation speed sensor and said axial speed sensor operatively coupled to said controller, said adjustment to cause correspondence of said rotational speed with said measured axial speed to wind said fibers on said article in a helical pattern having a lay angle tolerance of about one-half degree;

a resin ring coupled to said winding station adapted to apply resin to said fibers prior to winding on said article, said resin ring comprising a rotationally fixed inlet for said resin, an inflatable seal adapted to seal a fiber inlet and a fiber outlet of a chamber wherein said resin is applied to said fibers, said chamber having formed surfaces therein so that said fibers change directed as they pass through said chamber;

a controllable force brake rotationally coupled to said bobbin, said brake selectively operable to maintain a substantially constant tension on said fibers as said fibers are wound onto said article; and

a detector adapted to detect torsional resonance in said winding station coupled to said controller, said controller adapted to adjust said rotational speed of said winding station and said speed of axial motion of said article to avoid said torsional resonance.

52. A system for winding fibers onto an article, comprising:

a winding station having a controllable speed of rotation, said winding station having at least one fiber bobbin thereon;

a conveyor adapted to move said article axially through said winding station; and

a detector adapted to detect resonance in axial motion of said article through said system, said axial resonance detector and said conveyor coupled to a controller, said controller adapted to adjust an axial speed of motion of said article when axial resonance is detected.

53. The system as defined in claim 52 wherein said axial resonance detector comprises a current measuring circuit coupled to a motor adapted to drive said conveyor.

54. The system as defined in claim 52 wherein said axial resonance detector comprises a torque sensor coupled to a motor adapted to drive said conveyor.

55. The system as defined in claim 52 wherein said axial resonance detector comprises an axial motion sensor operatively coupled to said article as it passes through said system.

56. A system for winding fibers onto an article, comprising:

a winding station having at least one fiber bobbin thereon;

a conveyor adapted to move said article axially through said winding station; and

a brake rotationally coupled to said at least one fiber bobbin, said brake selectively operable to maintain a selected tension on said fibers as said fibers are wound onto said article;

a sensor for measuring an external diameter of said article after winding said fibers thereon; and

a controller coupled to said brake and said sensor, the controller adapted to adjust said selected tension of said fibers in response to changes detected in said external diameter by said sensor.

57. The system as defined in claim 56 wherein said winding station has a controllable speed of rotation and said controller is adapted to change a rotation rate of said winding station in response to changes in said external diameter.

58. The system as defined in claim 56 wherein said brake is operated to increase said tension when said sensor detects an increase in said external diameter.

59. A system for winding fibers onto an article, comprising:

a winding station having at least one fiber bobbin thereon, said winding station having a controllable rate of rotation;

a conveyor adapted to move said article axially through said winding station as said fibers are wound onto said article;

a sensor for measuring an external diameter of said article after winding said fibers thereon; and

a controller coupled to said sensor and adapted to adjust said controllable rate of rotation of said winding station in response to changes in said external diameter measured by said sensor.

60. The system as defined in claim 59 further comprising a brake rotationally coupled to said at least one fiber bobbin, said brake selectively operable to maintain a selected tension on said fibers as said fibers are wound onto said article, said controller adapted to adjust said selected tension in response to changes in said external diameter.

Sub A1